PB80-201809

Evaluation of Motor Vehicle Emissions Inspection Maintenance Programs for Michigan
Volume I. Executive Summary

Pacific Environmental Services, Inc.
Santa Monica, CA

Prepared for

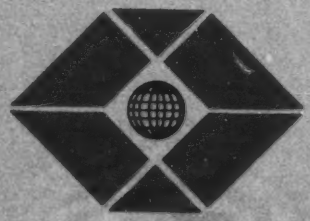
Environmental Protection Agency, Chicago, IL
Region V

15 Oct 79

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA-905/2-79-003A

PB80-201809



Pacific Environmental Services, INC.

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SPRINGFIELD, VA. 22161

EVALUATION OF MOTOR VEHICLE EMISSIONS INSPECTION/MAINTENANCE PROGRAMS FOR MICHIGAN

EXECUTIVE SUMMARY

CONTRACT NO. 68-02-2536
Task Order No. 7

Volume I

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region V
Chicago, Illinois

Submitted by:

PACIFIC ENVIRONMENTAL SERVICES, INC.
465 Fullerton Avenue
Elmhurst, Illinois

and

Systems Control, Inc.
Environmental Engineering Division
Anaheim, California

Pacific Environmental Services, INC.

CORPORATE AND ENGINEERING 1930 14th Street Santa Monica, California 90404 Telephone (213) 450-1800
MIDWEST OPERATIONS 465 Fullerton Avenue Elmhurst, Illinois 60126 Telephone (312) 530-7272

EVALUATION OF MOTOR VEHICLE EMISSIONS INSPECTION/MAINTENANCE PROGRAMS FOR MICHIGAN

EXECUTIVE SUMMARY

1.0 OVERVIEW

Pursuant to United States Public Law 95-95, otherwise known as the Clean Air Act as Amended (1977), all states are required to demonstrate the attainment by December 1982 of the national ambient air quality standards for carbon monoxide (CO) and ozone (O_3) in every part of the state. This demonstration is part of a State Implementation Plan (SIP) to be approved by the United States Environmental Protection Agency (EPA) no later than July 1, 1979. For most states, this has required the adoption of special pollution control measures in order to attain the standards and maintain them beyond 1982. If an area is unable to demonstrate attainment of standards by the stated date, despite implementation of various controls, an extension of the attainment deadline to 1987 may be granted to the state under certain conditions specified in the Act. One of these conditions is that an emissions Inspection/Maintenance(I/M) program for motor vehicles be initiated in all areas of the state that will fail to meet the standards by December 31, 1982. It is EPA policy that the latest permissible start-up date for such a program is December 31, 1981 if vehicle inspections are to be conducted at decentralized (private) facilities, and December 31, 1982 if the inspections are to be performed at centralized special testing stations operated either by the state or by a private contractor.

The purpose of I/M is to identify vehicles with pollutant emissions in excess of levels considered acceptable. It is required that vehicles so identified must be repaired or adjusted. I/M may be considered a quality assurance mechanism in support of the Federal Motor Vehicle Control Program which since 1970 has set new vehicle emissions standards for present and future model years and requires emission control equipment on new vehicles.

The State of Michigan must consider candidate I/M programs for implementation in all or parts of the State, because the five-county Detroit metropolitan area, at least, is expected to be unable to meet applicable air quality standards prior to the 1982 deadline. Officially, 37 counties of southern Michigan, as well as Marquette County in the Upper Peninsula, have been designated ozone nonattainment counties (Fig. 1). EPA has determined that reduction of emissions of reactive hydrocarbons (HC), a major portion of which is attributable to the operation of motor vehicles, is necessary for the reduction of ambient O_3 levels, and can be achieved through I/M. Failure to address the issue of I/M could result in disapproval of the Michigan SIP, which in turn would result in the imposition of restrictions on industrial growth and possible federal funding sanctions on the State. Because of the significant effort involved in developing the information needed to meet the Clean Air Act requirements that mandate legal authority for I/M no later than July 1, 1979, EPA provided funding for Michigan to secure contractual assistance for the performance of necessary technical studies of I/M. Pacific Environmental Services, Inc. (PES) and Systems Control, Inc. (SCI) were selected to evaluate a range of possible I/M program configurations to assist in the identification of a short list of alternatives that would be appropriate in Michigan. The findings of the evaluation are presented in the two volume study that accompanies this summary.

1.1 STUDY OBJECTIVES

There were five principal objectives of this study.

1. Explore a broad range of program options.

2. Perform a comprehensive evaluation of the costs and benefits of seven principal or "base" options that together incorporate all the unique properties of program configurations suggested by representatives of the State of Michigan.

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COUNTIES

1. ALCONA
2. ALGER
3. ALLEGAN
4. ALPENA
5. ANTRIM
6. ARENAC
7. BARAGA
8. BARRY
9. BAY
10. BENZIE
11. BERRIEN
12. BRANCH
13. CALHOUN
14. CASS
15. CHARLEVOIX
16. CHEBOYGAN
17. CHIPPEWA
18. CLARE
19. CLINTON
20. CRAWFORD
21. DELTA
22. DICKINSON
23. EATON
24. EMMET
25. GENESEE
26. GLADWIN
27. GOGEBIC
28. GD. TRAVERSE
29. GRATIOT
30. HILLSDALE
31. HOUGHTON
32. HURON
33. INGHAM
34. IONIA
35. IOSCO
36. IRON
37. ISABELLA
38. JACKSON
39. KALAMAZOO
40. KALKASKA
41. KENT
42. KEWEENAW
43. LAKE
44. LAPEER
45. LEELANAU
46. LENAWEE
47. LIVINGSTON
48. LUCE
49. MACKINAC
50. MACOMB--METRO
51. MANISTEE
52. MARQUETTE
53. MASON
54. MECOSTA
55. MENOMINEE
56. MIDLAND
57. MISSAUKEE
58. MONROE
59. MONTCALM
60. MONTMORENCY
61. MUSKEGON
62. NEWAYGO
63. OAKLAND--METRO
64. OCEANA
65. OGEMAW
66. ONTONAGON
67. OCEOLA
68. OSCODA
69. OTSEGO
70. OTTAWA
71. PRESQUE ISLE
72. ROSCOMMON
73. SAGINAW
74. SANILAC
75. SCHOOLCRAFT
76. SHIAWASSEE
77. ST. CLAIR-METRO
78. ST. JOSEPH
79. TUSCOLA
80. VAN BUREN
81. WASHTENAW
82. WAYNE---METRO
83. WEXFORD

Figure 1. MICHIGAN OZONE NONATTAINMENT COUNTIES

3. Develop estimates of program costs and consumer fees for a matrix of 24 program configurations expanded from the base options and differentiated by administrative mode, inspection mode, and scope.

4. As a result of this comparative analysis and consultation with concerned representatives of Michigan, eliminate from the matrix those candidate programs determined to be either unsatisfactory or inappropriate for the State.

5. Prepare a program plan for further detailed study of a specific inspection/maintenance program for Michigan.

Volume 1 of the report addresses the first objective, while Volume 2 presents the results of the analyses undertaken for objectives 2, 3, and 4. The recommended program plan for further study has been submitted under separate cover.

1.2 BASIC FEATURES OF INSPECTION/MAINTENANCE

Volume 1 of the report introduces the basic elements and issues of an I/M program.

EPA policy requires that an approvable I/M program must be able to produce by the end of 1987 a 25 percent net reduction in emissions of HC and CO from light-duty vehicles (LDV) compared to what these emissions would be without this program. Additional emission reductions may be achieved if a state includes testing of other vehicle categories, such as heavy-duty gasoline trucks. Vehicle categories that a state may consider for emissions testing in an I/M program include the following:

a. Light-duty vehicles weighing less than 6,001 pounds
b. Medium-duty vehicles (generally trucks) weighing from 6,001 to 8,500 pounds
c. Heavy-duty (greater than 8,500 pounds) gasoline vehicles (HDG)
d. Heavy-Duty (greater than 8,500 pounds) diesel vehicles (HDD)
e. Motorcycles

The overall potential for emissions reduction is also sensitive to the geographical scope of program coverage. Six geographic areas of

Michigan have been identified as meeting appropriate criteria for implementation of I/M. These areas are listed below in descending order of size. Again, it should be noted that an I/M program is mandatory only in a region in which attainment by 1982 of CO and/or O_3 standards cannot be demonstrated. Nonetheless, it is true that more comprehensive geographic coverage results in greater total emissions reduction.

Potential geographic coverage:

a. Entire state (83 counties)

b. Ozone nonattainment counties of lower peninsula (37 counties)

c. Ozone nonattainment metropolitan counties
   Detroit (Macomb, Monroe, Oakland, Washtenaw, and Wayne) - also includes CO nonattainment area
   Lansing (Clinton, Eaton, and Ingham)
   Grand Rapids (Ottawa and Kent)
   Flint (Genesee)

Two elements of candidate I/M programs that do not affect the magnitude of emissions reduction, but nevertheless, are the principal characteristics distinguishing one candidate from another are the administrative arrangements and method of emissions inspection. These elements are discussed below.

Several possible administrative approaches have been evaluated for the State of Michigan. These arrangements describe the operational format of the inspection phase of I/M, and would be characterized by one of the following.

- State-owned/operated centralized facilities, in which a public authority of the State of Michigan would manage and operate publicly-owned test facilities.

- Contractor-owned/operated centralized facilities, in which a private firm or other entity selected through competitive bidding would be delegated operational responsibility for inspection. The contractor and not the State would assume financial responsibility for constructing and operating test centers. Administrative overview and monitoring would remain the responsibility of a public authority.

- Inspection of a statistical sample of vehicles at state- or contractor-owned/operated facilities, in which a stratified, randomly-sampled percentage of the Michigan vehicle population would be tested to determine if the vehicles are tuned and operating generally within manufacturers specifications. The objective of this approach would be to establish whether or not a full-scale I/M program is needed in Michigan, and if such a program would accomplish its intended goal of emission reduction.

- Privately-owned/operated decentralized facilities, in which the State of Michigan would certify qualified establishments (independent service garages and dealerships) to perform inspections. The State would oversee and regulate the program to ensure that I/M requirements and provisions are met.

All I/M programs currently in operation utilize either centralized facilities operated by public authority or contractor or decentralized private garages for vehicle inspection. For all administrative approaches except statistical sampling, repair of vehicles which fail an emissions inspection would be mandatory. Repairs would be performed by dealerships, service garages and independent operators comprising the automotive service industry.

Three emission inspection procedures have been evaluated for implementation in an I/M program for Michigan. These are:

- the idle-mode test,
- the loaded-mode test, and
- an engine parameter/device inspection (EPDI).

Moreover, it has been proposed that an inspection for safety defects and excessive noise be incorporated into the emissions inspection procedure. That is, safety and noise tests would be performed at emissions inspection stations, most likely at positions specially equipped for such testing.

The idle mode test consists of measuring tailpipe exhaust emissions with the vehicle idling in neutral gear. Hydrocarbon and carbon monoxide levels are measured at both normal and high-idle speed. The test at the normal-idle speed is conducted at the vehicle manufacturer's recommended idle (600 to 1,000 revolutions-per-minute) while the high-idle test is conducted at 2,500 rpm. Emissions are collected by a tailpipe probe. The general characteristics of idle-mode testing include:

- Simplicity, requiring minimal training for inspectors
- Limited diagnosis of some engine maladjustments and malfunctions
- High probability that test conditions can be duplicated by private garages for repair diagnosis
- Brief test time and minimal equipment requirements
- Inability to detect some emission control system malfunctions that would occur when a vehicle is operating under road-load and higher speeds
- Inability to detect elevated emissions of nitrogen oxides (NO_x), a regulated pollutant
- Opportunity to perform minor carburetor adjustments during testing.

The results of any approvable short emissions test must correlate satisfactorily with results obtained from the Federal Test Procedure (FTP). FTP is EPA's baseline inspection cycle of over forty minutes' duration which requires a twelve-hour engine-off preconditioning period ("cold soak") for each vehicle tested. To date, EPA has not released a list of approved short cycle emissions tests. However, it is anticipated that the idle mode inspection procedure will be approved.

The loaded mode test may also be approved. This inspection procedure requires the use of a chassis dynamometer and, if specified, a gas analyzer for oxides of nitrogen (NO_x) in addition to the standard HC and CO analyzers. It has been determined from experimentally-derived data that most high contaminant emissions result from specific engine maladjustments or malfunctions that come to light under different engine speed and road-load conditions. Therefore, it is advisable that several different load conditions be applied to a vehicle during emissions inspection. One version of a loaded-mode test, called the transient-mode or Federal short-cycle inspection, analyzes emission samples from nine operating modes (simulated after vehicle positioning on the dynamometer) ranging from idle through acceleration to high cruise and deceleration over a time period of 125 seconds. The disadvantage of the Federal short-cycle test is that it is very equipment-intensive, requiring all equipment used in the FTP. By contrast, most loaded-mode testing

conducted in ongoing I/M programs employs a limited selection of typical test speeds which usually include only high cruise (44 to 50 mph), low cruise (22 to 30 mph) and idle. Exact test speeds and loads would depend on vehicle weight. Different failure limits are established for the HC and CO (and NO_x) concentrations for each operational mode and vehicle model year. Better diagnostic information can usually be obtained from a loaded test because failures at non-idle modes generally point to a specific and identifiable malfunction referenced in a logic diagram or "truth chart." However, unless mechanics are extensively trained in the proper use of loaded test diagnostic information, the diagnostics do not result in emissions reduction greater than that which is obtainable from the idle mode test.

For the engine parameter/device inspection (EPDI), vehicles are subjected to a sequence of system component checks to determine the mechanical condition of various emissions-related systems. Components and/or operating parameters outside the accepted tolerance range are considered to have failed, and are required to be replaced or adjusted to manufacturer's specifications. This approach does not specifically include measurement of emissions levels, although in some cases, emission measurements would be taken to evaluate the state of vehicle systems such as oxidation and reduction catalysts. The diagnostic capabilities of the EPDI are probably the greatest of any of the short emissions tests discussed here.

The following sequence is generally applicable to any emissions testing procedure. Upon its arrival at an inspection facility, (1) the registration/license number of a vehicle and other pertinent information on vehicle characteristics are recorded. This is followed by (2) visual inspection of the exhaust system and emission control devices, (3) the exhaust emission test, (4) recording of test data, (5) notification of test results to the motorist, and (6) issuance of certificate (compliance, failure, or waiver). Figure 2 illustrates this sequence. For a drive-through facility with three positions per inspection lane, steps 1 and 2 above would occur at position one, steps 3 and 4 at position two, and

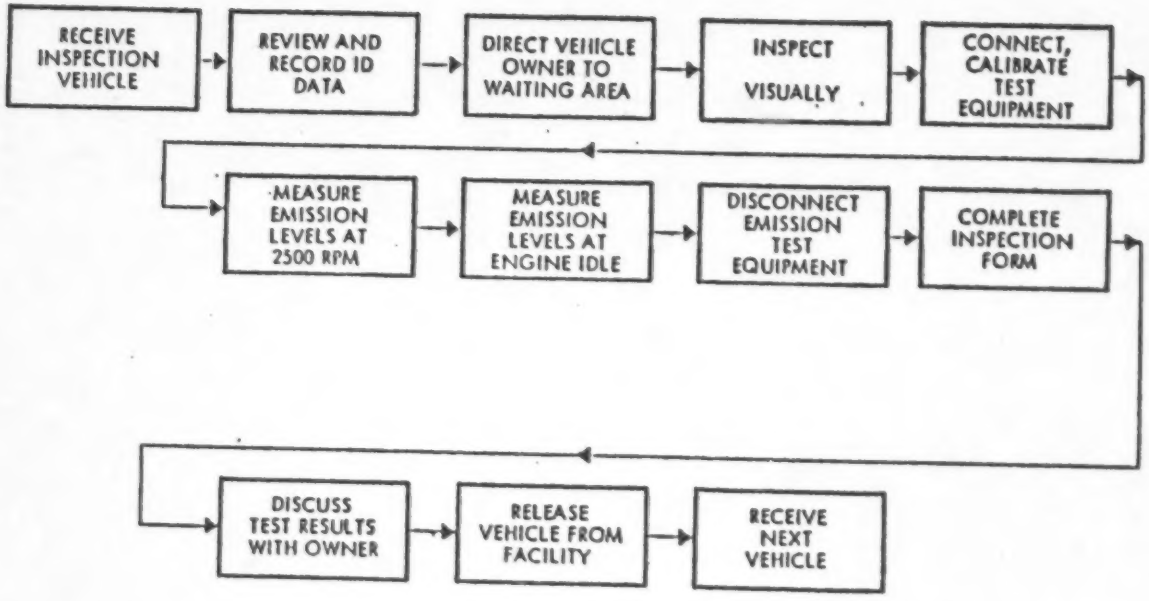
RECEIVE INSPECTION VEHICLE
REVIEW AND RECORD ID DATA
DIRECT VEHICLE OWNER TO WAITING AREA
INSPECT VISUALLY
CONNECT, CALIBRATE TEST EQUIPMENT
MEASURE EMISSION LEVELS AT 2500 RPM
MEASURE EMISSION LEVELS AT ENGINE IDLE
DISCONNECT EMISSION TEST EQUIPMENT
COMPLETE INSPECTION FORM
DISCUSS TEST RESULTS WITH OWNER
RELEASE VEHICLE FROM FACILITY
RECEIVE NEXT VEHICLE

Figure 2. Typical Inspection Sequence

steps 5 and 6 at position three. These positions are respectively termed the receiving station, test station, and certification station. Data handling operations may be fully automated or manual, with automated data handling the rule at centralized inspection facilities. Based on the exhaust emission test data, a pass/fail decision is made and discussed with the vehicle owner. Passed vehicles are certified, but impending malfunctions are flagged. Failed vehicles are diagnosed as to the probable cause of failure, then released to the motorist for required repair. Certain vehicles may be granted a waiver from further testing but, in general, failed vehicles must return to an inspection station following repair for a retest.

The proposed inclusion of safety testing as part of an emissions inspection program was prompted in part by the Michigan Trial Substitute Vehicle Inspection Program, conducted during 1975 and 1976 at random check lanes in two Michigan counties. The following items were checked as part of this program.

- Vision defects (glass, wipers, washers, mirrors)
- Lighting defects
- Exhaust defects (noise and smoke)
- Control defects (steering, brake and tire condition)
- Miscellaneous deficiencies (horn, registration, and seatbelts)

Among the findings of this program, which is no longer in operation, was that the overall rate of inspection failure was relatively insensitive to sample size.

Vehicle-in-use standards and periodic motor vehicle inspection programs presently operating in other states emphasize safety-related components. There is a general belief that vehicles in good operating condition are less likely to be involved in accidents. The safety inspection envisioned for Michigan would involve quick visual checks of the parameters mentioned above and a brake test using the skid plate method which is described in Volume 2, Section 3.3.1 of the report.

The State of Michigan has already established procedures and standards for drive-by and stationary noise levels. However, the procedure is not compatible with indoor test facilities in which a large hard-surface testing site and low ambient noise levels cannot be assured. Simple stationary tests correlatable with federal pass-by procedures would be needed for integration into an I/M program. If such tests can be developed and specified, and their space requirements are not extensive, one or more may be performed at an emissions inspection facitlity.

1.3 EXPLORATION OF SPECIFIC PROGRAM OPTIONS

Volume 2 of the report is devoted to an in-depth examination of the characteristics of the specific I/M program options that may be considered for implementation in Michigan. The various benefits and economic effects attributable to I/M generally are discussed in a Michigan context. Also discussed are ancillary issues of program implementation and operation (including quality assurance of testing, consumer protection for repair, public information strategies and mechanic training programs) that must be addressed in any program regardless of administrative approach or method of test. Cost categories for the program are identified and explained; then, total life costs and annual consumer fees are developed for a comprehensive set of seven basic and seventeen additional program options. Based on a comparison of costs, the qualitative merits of each option and extensive consultation with State of Michigan Technical Advisory Committees for air quality and inspection/maintenance, the total number of candidate options is reduced to a set of two firm and one conditional program configurations for further study. These configurations are discussed in Section 1.5 of this Summary.

The primary purpose and principal benefit of an Inspection/Maintenance program is the reduction of vehicular emissions. However, there are associated benefits and positive effects of a successful I/M program in the realm of monetary savings and improved driveability for the individual and certain direct and indirect economic effects. Section 2.0 of Volume 2 introduces and expands upon the benefits of I/M applicable to Michigan.

Table 1 presents the total emission reductions that would result from an I/M program covering all light-duty vehicles (less than 8,500 pounds) in each of the State's five nonattainment metropolitan areas, under the assumption that 20 percent of vehicles tested would fail the emissions inspection and undergo repair. It is further assumed that trained mechanics perform these repairs. Values in the table were supplied by the Michigan Department of Transportation and the Southeastern Michigan Council of Governments, and were generated using EPA's MOBILE 1 computer program which computes vehicle emission factors under a wide variety of assumptions and incorporates the emission reduction credits attributed to an I/M program by EPA (based upon values presented in Appendix N of Part 51 of Volume 40, Code of Federal Regulations). Other program benefit issues discussed in Vol. 2, Section 2.0 are the likely increases in fuel economy, improved vehicle performance and vehicle life attributable to the identification and correction of out-of-tune and malfunctioning vehicles; the identification of warranty parts failures; employment generation and other economic growth effects attributable to the technical and material requirements of I/M; the "banking" of emission reduction credits through I/M in order to protect future industrial growth in Michigan; and miscellaneous difficult-to-quantify effects including reduced health-related costs and improved visual esthetics attributable to cleaner air. In general, assignable benefits are insensitive to program administration and method of test (with those test procedures for which EPA has acknowledged emission reduction benefits) but vary with geographical scope of coverage and by type and population of the vehicles subject to inspection.

Table 2 presents the matrix of 24 program options evaluated for Michigan. The "base options" incorporating all unique program features with repsect to administrative approach, method of test, and program objectives, are identified in the table by asterisks. For each base option output capabilities for an inspection lane were computed on the

Table 1. INSPECTION/MAINTENANCE PROGRAM RESULTS IN MAJOR URBAN AREAS IN THE DESIGNATED NONATTAINMENT REGION

		Detroit*	Flint	Lansing	Grand Rapids	Niles
CO						
1982:	No I/M	3,885,672	168,420	135,129	182,651	9,557
	I/M 1 year	3,512,449	146,679	117,530	158,860	8,305
	% Decrease	9.6	12.9	13.0	13.0	13.1
1987:	No I/M	2,346,511	92,333	78,492	101,874	5,514
	I/M 5 years	1,746,443	58,196	49,401	64,085	3,433
	% Decrease	25.6	37.0	37.0	37.0	37.7
HC						
1982:	No I/M	352,863	20,527	17,135	21,087	1,066
	I/M 1 year	340,469	19,680	16,449	20,166	1,017
	% Decrease	3.5	4.1	4.0	4.4	4.6
1987:	No I/M	204,066	10,868	9,424	11,648	622
	I/M 5 years	159,350	7,882	6,883	8,349	439
	% Decrease	21.9	27.5	27.0	28.3	29.4

Figures are kilograms per average-summer-day for 20 percent failure rate not including mechanics training

*Values supplied by Southeastern Michigan Council of Governments. Hydrocarbon totals for Detroit include only reactive HC.

Note: I/M program presumed to include 20 percent failure rate (stringency factor) and repairs by trained mechanics.

Table 2. ALTERNATIVE APPROACH VERSUS METHOD OF TEST

ADMINISTRATIVE APPROACH	METHOD OF TEST		
	IDLE	LOADED	EPDI
State-Operated	1. without safety & noise*	9. without safety & noise*	17. without safety & noise*
	2. with safety & noise*	10. with safety & noise	18. with safety & noise
Contractor-Operated	3. without safety & noise*	11. without safety & noise	19. without safety & noise
	4. with safety & noise	12. with safety & noise	20 with safety & noise
Service Center (Private Garage)	5. without safety & noise*	13. without safety & noise	21. without safety & noise
	6. with safety & noise	14. with safety & noise	22. with safety & noise
Statistical Sampling	7. without safety & noise*	15. without safety & noise	23. without safety & noise
	8. with safety & noise	16. with safety & noise	24. with safety & noise

* base option

basis of time required to perform a single inspection (by test mode and scope) factored by an empirically-derived percentage multiplier of actual versus ideal efficiency. The output computation procedure for each mode of test is discussed in Section 3.6.2 of Volume 2. The following annual lane capacities were developed for a testing program involving light-duty vehicles (LDV).

Idle mode	23,000 LDV
Loaded mode	19,200 LDV
Engine Parameter/Device Inspection	4,500 LDV

Based on these values and the required staffing complement per inspection facility, total personnel and lane requirements were developed by county using projected vehicle registration for 1987. Given capacity and personnel requirements it became possible to identify specific values by program option for each of the cost elements shown in Table 3. We shall return to this table presently.

I/M program requirements that may result in public and private costs directly attributable to the program are introduced in Section 3.8 of Volume 2 and discussed in depth in appendices to the report. Individual states are responsible for obtaining the legal authority to implement vehicle Inspection/Maintenance programs. Michigan does not currently have enabling legislation. The legislation will be requested during the fall of 1979. Legislation may be very general, or may be very specific and assign all reponsibilities for the program, determine testing procedures, and even set emission standards. Preparation of this legislation will require considerable devotion of time and effort by elected officials and staff of the State of Michigan. Appendix B of Volume 2 presents a detailed discussion of the issues that should be considered for inclusion in I/M legislation.

While I/M legislation is debated and after its passage by the Legislature, the citizens of Michigan must be informed of all aspects of the impending program which will have an impact on their accustomed activities. The basic features of a public information effort and a suggested timeline for implementation of the various stages are presented in Appendix C.

Table 3. COST ELEMENTS

ITEM	COST ELEMENT
I.	INITIAL IMPLEMENTATION AND CAPITAL COSTS (NONRECURRING)
	A. Initial Implementation Costs
	1. Site Selection
	2. Bids Preparation and Evaluation
	3. Facilities Design
	4. Training Plan Development
	5. Personnel Selection
	6. Document Preparation
	7. Administrative Support
	8. System Integration, Checkout, and Certification
	9. Test Scheduling System Development
	B. Capital Costs (Construction)
	1. Land and Site Improvement Costs
	a. Land Cost
	b. Site Improvement Costs
	2. Facility Construction
	3. Instrumentation Cost
	4. Office Equipment
	5. Computer Costs
	a. Hardware
	b. Software
	C. Capital Costs (Other)
	1. Administrative Office Equipment
	2. Quality Control Equipment
	a. Mobil Unit
	b. Referee Station
	c. Correlation Car
	3. Consumer Complaint
II.	ANNUAL OPERATING COSTS
	A. Facility Operating Costs
	1. Personnel Costs
	2. Maintenance and Miscellaneous Item Costs
	a. Facility
	b. Equipment
	B. Support Costs
	1. Administrative
	2. Data Analysis
	3. Training
	C. Quality Control Operating Costs
	1. Personnel
	2. Supply
	3. Maintenance
III.	ANCILLARY PROGRAMS ANNUAL OPERATING COSTS
	A. Mechanic Training
	B. Public Information Program
	C. Consumer Complaint
	D. Vehicle Test Scheduling Costs

An I/M program will fully succeed with respect to its intended purpose and to the satisfaction of the public only if qualified mechanics perform the repairs necessary to bring polluting vehicles into compliance with standards. Michigan is fortunate to have a vehicle mechanic and repair facility certification and registration system already in place, which will greatly ease the problem of identifying qualified mechanics to perform vehicle repairs. However, additional mechanics must be trained and many mechanics retrained for perform the necessary repairs. Appendix D presents the elements of a mechanics program, discusses the two-phase training approach recommended by State of Michigan staff, and provides an appropriate program timeline. Costs developed for the training effort are incorporated in the detailed option cost analyses of Volume 2, Section 5.0.

Any vehicle owner subject to inspection/maintenance should expect that accurate, consistent inspections will be performed on his or her vehicle, and that there will be protection from improper and unnecessary repairs in the event of failing the test. Further, the owner should be assured that the motorist seeking to circumvent the system (and thus to neutralize the contribution the honest owner is making to clean air through proper vehicle maintenance) will be identified and that such cheating will be minimized. Mechanisms to assure accurate inspections at testing facilities include state-operated referee lanes or challenge garages (for complaint handling), mobile quality assurance vans equipped with instrument and gas calibration devices, correlation vehicles for comparative evaluation of test results from lane to lane, and a regular, internal, rigorously-observed schedule of instrument calibration and equipment maintenance. These mechanisms are all legitimate program costs directly assignable to the State and the operator(s) of the inspection facilities. For quality-assured repairs the present repair facility certification program in Michigan could be supported by periodic State inspections of garages and emission analyzers. Mechanics must also be instructed that they should tune a failed vehicle to manufacturer's specifications. Appendix E discusses these mechanisms in greater detail, reviews the most common means by which some motorists would attempt to cheat the system and

identifies effective methods for their prevention. The costs of appropriate quality assurance elements have been included in the total program cost analysis for each program option.

1.4 PROGRAM COST ELEMENTS AND COSTING METHODOLOGY

Development of total program costs for each of the seven base options of Table 2 is based on a life cycle cost model which sums annual operating costs and amortized implementation and capital costs over the life of the program, and develops annualized program costs. The three principal cost categories are Initial Implementation Costs which are those expenditures required to bring a given I/M concept to the point of implementation and include design, development, documentation, training, and support personnel costs; Capital Costs which are those expenditures required for obtaining and improving land for facility sites, constructing the facilities,and procuring testing and support equipment; and Annual Operating Costs which are those expenditures necessary to administer, operate, and maintain inspection facilities and provide appropriate quality assurance, consumer protection and public information on an ongoing basis. The specific elements of each cost category are listed in Table 3 and explained in Sections 4.2.1 through 4.4.4 of Volume 2. The cost methodology is based on the following principal assumptions.

- Five-year life of program
- Amortization period of five years for equipment costs, twenty years for building costs, and perpetuity (constant value) for land
- All fringe costs to state and contractor are included
- Vehicle population growth rate of 2.8 percent per year
- Land cost estimates per square foot vary by density of land development
- Unit costs for facility construction are uniform for all options
- All costs are expressed in 1978 dollars

For the base options costing, costs were developed for a program that would cover the ozone nonattainment counties (Figure 1), which include the carbon monoxide nonattainment area of metropolitan Detroit. Only light-duty vehicles would be covered by inspection. For determining total capacity requirements, the vehicle failure rate is conservatively assumed to be 30 percent. Tests would be conducted at one or two-lane facilities using the three-position lanes described earlier. Options incorporating safety and noise testing use five position lanes. "Worst case" travel distance to a test facility (maximum) is 30 miles. An initial work schedule of 8 hours/day, 250 days/year (2,000 total hours) is assumed. The mandatory program would start January 1, 1983 utilizing implementation and construction funds made available by the end of 1982, and no additional facilities would be constructed during the life of the program; that is, vehicle population growth during 1983-87 would be accommodated by additional hours of operation.

The selected base options, and reasons for their selection, are described below. Option numbers reference Table 2.

a) State-operated, idle mode with automated testing and data processing but without safety and noise inspection (Option 1). This program is representative of any state-operated program that would involve all LDV's in the given study area.

b) State-operated, idle mode with automated testing and data processing and including safety and noise inspection (Option 2). This option develops the cost for incorporating safety and noise tests as part of the total testing procedure. This cost remains uniform (by geographic area) across all administrative or emissions test mode options.

c) Contractor-operated, idle mode with automated testing and data processing without safety and noise inspection (Option 3). This program is representative of any contractor-operated option but with cost requirements at the lowest level for any contracted system.

d) Private garage (decentralized), idle mode with manual testing and data processing without safety and noise inspection (Option 5). This was deemed the most feasible and probably lowest (total) cost representative of the range of private garage options.

e) State-operated, statistical sampling program with automated idle mode testing and data processing and no safety and noise check (Option 7). The State of Michigan has had experience with a program that statistically sampled vehicles for defects in safety-related equipment. The findings of this study indicated that the incidence of malfunction was relatively insensitive to the size of the sample. Therefore, statistical sampling for vehicle emission control malfunction could prove as effective as the safety testing program in identifying gross emitters. The selected option would be the least complicated of the statistical sample options, presuming the sampling rate to remain constant, across all possible configurations.

f) State-operated, loaded-mode with automated testing and data processing and without safety and noise testing (Option 9). This is the baseline representative of possible loaded mode configurations, selected specifically for cost comparison with Option 1.

g) State-operated, EPDI inspection without safety and noise check (Option 17). This option was selected specifically for cost comparison with Options 1 and 9.

Program cost development procedures are detailed in Appendix F to Volume 2, and program cost tables are presented in Section 5.0. The computed annual inspection fee per tested vehicle (1978 dollars) ranged from $5.32 for Option 1 to $21.85 for Option 17. For each option involving either a contracted or private garage testing program, a share of the fee is allocated for State costs and the remainder for the contractor or garage costs. Table 4 provides complete fee information for each of the options.

In order to develop program costs and fees for the entire set of program options, line-item sensitivity factors to estimate the costs for variation among key program elements were developed and are presented in tabular form in Volume 2, Section 6.0. An I/M program in Michigan will involve one of three inspection modes, any of six geographic areas, one of five program stringency factors (standards set such that 10, 20, 30, 40, or 50 percent of vehicles fail the inspection), one of three administrative approaches and any of six vehicle types. The values of Tables 6-2 through 6-5 of Section 6 express the sensitivities to cost (that is, the variation from the identified baseline of two-lane inspection stations

for LDV testing throughout the O_3 nonattainment area) experienced as one moves along the range of possible combinations of each of the key program elements. Computations employing these factors generated a total program cost and fee breakdown for each of the remaining seventeen options of Table 2. These values are tabulated in Section 6, Table 6-1.

Table 4

	CONSUMER FEE IN 1978 DOLLARS		
OPTION NO.	STATE	CONTRACTOR OR GARAGE	TOTAL FEE
1	$ 5.32	$ .00	$ 5.32
2	7.04	.00	7.04
3	1.01	4.80	5.81
5	1.15	4.48	5.63
7	7.23	.00	7.23*
9	6.30	.00	6,30
17	21.85	.00	21.85

* This figure is reduced to $0.34 per owner if costs are equally allocated over the entire light-duty passenger vehicle population.

1.5 ELIMINATION OF UNSATISFACTORY OR INAPPROPRIATE OPTIONS

An objective of this study was to reduce the total number of candidate programs from twenty-four to a short list of three or fewer options to undergo further analysis in a later phase of the program. Although considerable information was derived from the alternatives costing analysis described above and from investigation of the relative advantages and disadvantages of the various options, it was desired to obtain additional comments and opinions on this issue from various groups representative of a larger constituency in the State of Michigan. Therefore, the decision on what options would comprise the short list was made only after extensive consultation with the Governor's Air Quality Review Committee, the Michigan Vehicles Inspection/Maintenance Advisory and

Technical Committees, the Legislative Advisory Committee, and guidance of U.S. EPA. It was also responsive to expressions of public opinion as obtained during the public hearings on the Michigan State Implementation Plan and through the medium of a public opinion poll conducted under auspices of the Michigan State Police, Office of Highway and Safety Planning.

The decision process resulted in the elimination of the following options. (Documentation of decisions is provided in Vol. 2, Section 7.0).

1. All inspection programs that include a safety and noise test.

   Key reasons were:

   - Mandatory safety and/or noise inspection programs are not currently operating in Michigan. While benefits may be realized from implementing these programs, neither will improve air quality, and both increase total program costs and costs to the consumer. The Michigan Legislature must decide if it is wise to go far beyond the intent of the Clean Air Act to include other programs within a program designed specifically to improve air quality.

   - States with safety programs currently operating question the effectiveness of safety inspections in reducing vehicle defect related accidents.

   - I/M programs that include safety and noise cost 30% more than programs testing emissions alone.

   - Experience from other safety and emissions testing programs indicates that over 50% of the tested vehicles fail the combined test. Costs for retesting failed vehicles will increase accordingly.

   - Average repair costs for vehicles needing repair will be higher.

   - Any I/M test mode is capable of identifying most of the vehicles that would fail a noise inspection, since most faulty mufflers or illegally modified exhaust systems are audible. In some cases faulty mufflers must be corrected prior to an emissions test, since exhaust leaks make it impossible to obtain accurate test results.

- Program implementation will take longer due to increased program complexity.

- It may be difficult to obtain legal authority for the combined program since the required legislation is much more complex and controversial than I/M legislation alone.

2. All options involving a statistical sampling program with participation not to exceed 25 percent of registered vehicles.

   Key reasons were:

   - It is not possible for the State of Michigan to demonstrate that the emission reduction from I/M required by EPA policy can be achieved by this program. This type of program may be able to demonstrate where overall emissions are, and what further reductions are possible through a vehicle I/M program.

   - Other control strategies either from stationary sources or from other transportation control strategies will be required to offset the shortfall in emission reductions obtained through this program.

   - This approach is not acceptable to the federal EPA, since it does fulfill the Clean Air Act Amendment requirement for I/M to be "mandatory and periodic".

3. All options involving a State-operated network of inspection stations.

   Key reasons were:

   - The initial costs to the State to implement the program are high.

   - There is uncertainty in obtaining required funds to implement the program.

   - Governmental employment will be greatly expanded as compared to other private sector administrative approaches.

   - There will be a loss of property tax revenues collected by local governments because taxes are not levied on State-owned facilities.

   - Flexibility to terminate the program is lacking.

   - Implementation time is likely to be greater due to the involvement of many state agencies, and because legal, financial, administrative, and hiring requirements are more complex in the public sector than in the private sector.

4. All options involving both initial emissions testing and repair at private garages.

   Key reasons were:

   - There is reluctance by the private sector and consumers to have private garages perform both the inspection and repair due to a potential and/or perceived conflict of interest.

   - A high turnover rate (10%/year) of garage ownership is experienced in Michigan. This makes it difficult to quantify program costs since the level of participation by garages is unknown.

   - Quality assurance costs are higher because instruments at many stations must be calibrated and checked for accuracy regularly. It is also necessary to check regularly for proper testing procedures and valid repairs.

   - More resources must be devoted to private garage licensing, quality control and complaint investigation than for the other administrative approaches.

   - So far, all of the states with private garage run I/M programs are states that had pre-existing safety inspection facilities. I/M was added onto their safety program. This substantially reduces planning time and capital required to implement the program. This is not the case in Michigan.

   - Most vehicles would have to be scheduled, by appointment, for inspection at a private garage, since most garages would be unable to achieve a high output rate. This increases the average workload at private garages and may increase average waiting times. In other inspection approaches, only the failed vehicles (20-30%) must schedule garage appointments. The overall effects of the added workload and its effect on program costs and consumer costs are not possible to predict at this time.

5. All options involving loaded-mode inspections (retaining the assumption that inspection stations could nevertheless be built to specifications that would accommodate such testing in the future.)

   Key reasons were:

   - The loaded mode test provides substantial diagnostic information. The benefit of the additional information is dependent on the mechanic's ability to use the diagnostics. So far there is no indication that mechanics effectively use this diagnostic information when repairing vehicles.

- A loaded test does not increase the amount of emission reductions obtained by the program.

- The repair industry may find it expensive and impractical to buy a dynamometer to duplicate loaded test results for repair purposes. If a repair garage cannot duplicate the test to see if repairs are correct there is a possibility of additional retests and additional consumer dissatisfaction.

- A loaded test costs 18% more than an idle test.

- If heavy duty vehicles are included in a loaded test I/M program, special double axle dynamometers will be necessary. This substantially increases program costs.

6. All options involving engine parameter/device inspection (EPDI).

   Key reasons were:

   - The parameter inspection defined in this report is approximately four times as expensive as an idle test.

   - Very little information is available pertaining to the test time (and subsequently output rate at inspection stations) involved in parameter testing.

   - I/M facilities for another test mode may be designed to include flexibility to change to a parameter/device inspection test mode. If a cost effective parameter test is developed this option may be chosen.

   - EPA has not established a method for calculating emission reduction credits for this test type. Currently, the burden of proof of emission reductions from this type of program is on the individual states.

Therefore, the remaining candidate options will be carried forward for additional study.

a. Contractor-operated idle mode testing and retesting at centralized facilities.

b. Contractor-operated idle mode testing with retesting at private garages (New Jersey-type program).

c. Alternative parameter inspections (as information becomes available).

The comparative advantages of a centralized, contractor-operated program were found to be greatest for the following reasons.

- The direct costs to the State of Michigan are lowest.
- Implementation procedures are straightforward.
- This approach ranks second only to a state-operated program with respect to assured quality and consistency of test.
- Idle mode inspections were determined to be the most cost-effective testing procedure.
- Inspection facilities will remain on municipal and county tax rolls.
- The program can be more easily terminated at the end of the period of contract.
- The opportunity for conflict of interest between inspection and repair is minimal.
- The report has shown that total program costs are not significantly greater than for a similar state-operated system.

The other two options carried forward were not identified for analysis in this phase of the study.